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# UNIVERSITY OF CALIFORNIA.

Department of Mechanical Engineering.

BULLETIN No. III.

# RESULTS OF TESTS

—— FOR ——

## TENSILE STRENGTH, ETC., OF CRUCIBLE BASIC, AND GALVANIZED BASIC STEEL WIRE ROPES, AND BASIC STEEL WIRE RODS,

MANUFACTURED BY THE

CALIFORNIA WIRE WORKS, SAN FRANCISCO, CAL.

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1885
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The mechanical laboratory is in posessson of a horizontal and a vertical testing machine of respectively 4,000 and 50,000 pounds capacity, manufactured by Richie & Brothers, Philadelphia, Pa., which were used in the following tests to our entire satisfaction.

Table 1 contains tests made of wires drawn from a number 6 soft Basic wire rod, gauge after gauge in succession down to and including number 16, and annealed after each drawing.

Table 2 contains the tests of wires drawn from the same rod number 6, as before, but which were not annealed after each drawing.

The annexed diagram gives a graphic representation of the results of 92 tests, made upon rods which were drawn from a number 8 soft Basic wire rod. The wire was successively subjected to an increasing load, and the extension measured.

All the samples sent for testing were from the ordering stock as manufactured by the company, and pains were taken to send only average pieces, none of which had been especially prepared for testing except the number 6 Basic steel wire rods, Thomas-Gilchrist process, which had been drawn, as stated, as far as it was safe to draw one gauge in size at a time.

Weights and extensions are marked respectively on vertical and horizontal lines.

From *A* to *B* the elongation was found to be proportionate to the force. At *B* the rate of elongation was in excess over that of the load, in fact, so decided was this change, that a careful observer was enabled to locate this point *B* within very close limits.*

Defining, with Fairbairn, the elastic limit as the maximum stress below which the elongation is directly proportional to the force, said point *B* was designated in the following tests as the limit of elasticity, with sufficient approximation.

This disproportionate elongation beyond *B* is continued, until at *E*, the ratio between elongation and load becomes again nearly constant until the point *C*, corresponding to the maximum load, was reached.

From *C* to *D* the diameter of the rod suffered a rapid reduction, under decreasing load, until the section reached a minimum at the place of rupture *D*. See Fig. II.

The application of the increasing loads followed each other in rapid succession, whereby the influence of the duration of the load was eliminated.

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*The exactness of these determinations was due to the skill of the Superintendent of the Laboratory, Mr. J. A. Sladky, under whose direction these experiments were made, and also to the kind coöperation of Prof. H. Kower, assisted by Messrs. Rixford and Raymond.

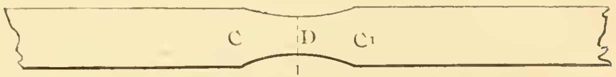

Fig. 2

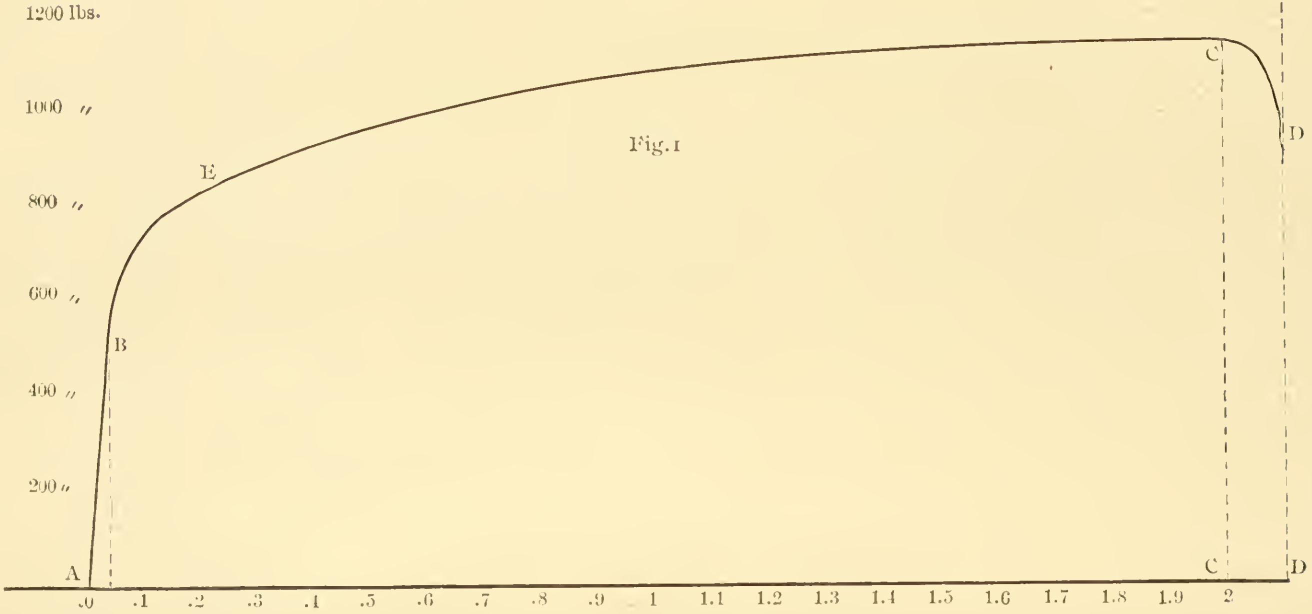

Fig. 1

D′ < length of test piece = 10.2″. Scale of extensions 3 times natural size.

The numbers at the head of the following tables indicate as follows:

1 Birmingham Gauge — B. W. G.
2 Actual diameter of original wire in inches.
3 Diameter of wire at *C*.
4 Maximum diameter of surface of rupture.
5 Minimum diameter of surface of rupture.

The surface at which rupture took place was found to be nearly elliptical. Its area was obtained by the product of these two diameters into .78.

6 Load at point *B*. Approximate limit of elasticity.
7 Carrying strength in pounds, (breaking strain).
8 Original length of wire.
9 Elongation to limit of elasticity, (*B*).
10 Elongation to point of rupture, (*C*).
11 Area of section of wire before test.
12 Area of section at which rupture took place.
13 Per cent. of reduction of area.
14 Load at limit of elasticity per square inch in pounds.
15 Carrying strength (ultimate breaking strain) per square inch in pounds.
16 Carrying strength (ultimate breaking strain) per square inch referred to section at which rupture took place.
17 Elongation per foot at limit of elasticity.
18 Elongation per foot at point *C* (total elongation per foot).

The local elongation from *C* to *D* being independent of length of wire, it was eliminated.

19 Weight of wire per foot in pounds.

The carrying strength (ultimate breaking strain) per square inch referred to that section at which rupture took place, given in column number 17, offers, according to Kirkaldy, the best criterion for comparison as regards quality of the material in general, since the choice of material in most applications rests not only upon the strength, but also upon its tenacity and ductility.

Inferior material may rank first if judged by its carrying strength alone. Compare the tables of v. Kaven, "Zeitschrift d. Hannoverishen Architecten and Ingenieur Vereins," 1868, pages 443–446. Also "Deutsche Industriezeitung," 1873, page 185, for tables published by the Department of Public Works in India, in accordance with the propositions and experiments of Kirkaldy in order to apply the same to the various kinds of iron in contracts and proposals.

# TABLE 1.

| I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | XIII | XIV | XV | XVI | XVII | XVIII | XIX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gauge, B. W. G. | Diameter of Original Wire, in Inches. | Diameter at C. | Maximum Dia. at Surface of Rupture. | Minimum Dia. at Surface of Rupture. | Approximate Limit of Elasticity. | Breaking Load. | Original Length of Wire. | Elong'n to Limit of Elasticity. | Elongation to Point of Rupture. | Sectional Area Before Test. | Sectional Area at which Rupture Took Place. | Per cent. of Reduction of Area. | Load at Limit of Elasticity. | Break'g Strength per sq. inch in Pounds. | Breaking Strain per sq. inch, ref. to sec'n of Rupture. | Elongation per foot at Limit of Elasticity. | Total Elongation per Foot. | Weight of Wire per Foot. |
| *6 | .166 | .157 | .105 | .078 | 940 | 1530 | 10.90 | .12 | 2.23 | .0216 | .00643 | .30 | 43500 | 70830 | 238000 | .13 | 2.40 | .074 |
| 7 | .164 | .152 | .112 | .082 | 725 | 1239 | 10.11 | .18 | 2.16 | .0243 | .00722 | .30 | 29800 | 51030 | 172000 | .21 | 2.46 | .034 |
| 8 | .162 | .147 | .076 | .071 | 675 | 1065 | 9.94 | .17 | 2.26 | .0205 | .00424 | .21 | 32900 | 51900 | 251000 | .20 | 2.62 | .070 |
| 9 | .149 | .134 | .070 | .068 | 620 | 930 | 10.10 | .20 | 2.10 | .0174 | .00374 | .21 | 35600 | 53400 | 249000 | .24 | 2.39 | .059 |
| 10 | .137 | .122 | .068 | .065 | 500 | 797 | 11.00 | .10 | 2.72 | .0148 | .00347 | .24 | 33800 | 53800 | 230000 | .11 | 2.84 | .050 |
| 11 | .120 | .108 | .062 | .053 | 414 | 610 | 10.25 | .30 | 2.26 | .0114 | .00262 | .23 | 36300 | 53500 | 236000 | .35 | 2.55 | .039 |
| 12 | .105 | .092 | .058 | .050 | 328 | 485 | 10.27 | .22 | 1.88 | .0086 | .00228 | .27 | 38150 | 56400 | 213000 | .26 | 2.11 | .030 |
| 13 | .090 | .083 | .052 | .040 | 250 | 367 | 10.10 | .56 | 2.39 | .0068 | .00163 | .21 | 36890 | 58200 | 225000 | .67 | 2.72 | .023 |
| 14 | .079 | .074 | .031 | .030 | 185 | 317 | 9.92 | .20 | 1.92 | .0049 | .00073 | .15 | 37800 | 62690 | 431000 | .24 | 2.23 | .017 |
| 15 | .069 | .066 | .029 | .025 | 160 | 257 | 9.75 | .10 | 1.91 | .0038 | .00057 | .15 | 42100 | 67600 | 451000 | .12 | 2.25 | .013 |
| 16 | .067 | .059 | .021 | .020 | 125 | 215 | 10.38 | .30 | 2.32 | .0036 | .00033 | .08 | 34700 | 59700 | 652000 | .35 | 2.56 | .012 |

* Wires of guage 6 and 16 were of different quality, the breaking strain of the other wires increased inversely as the diameters.

# TABLE 2.

| I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | XIII | XIV | XV | XVI | XVII | XVIII | XIX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gauge, B. W. G. | Diameter of Original Wire, in Inches. | Diameter at C. | Maximum Dia. at Surface of Rupture. | Minimum Dia. at Surface of Rupture. | Approximate Limit of Elasticity. | Breaking Load. | Original Length of Wire. | Elong'n to Limit of Elasticity. | Elongation to Point of Rupture. | Sectional Area Before Test. | Sectional Area at which Rupture Took Place. | Per cent. of Reduction of Area. | Load at Limit of Elasticity. | Break'g Strength per sq. inch in Pounds. | Breaking Strain per sq. inch, ref. to sec'n of Rupture. | Elongation per Foot at Limit of Elasticity. | Total Elongation per Foot. | Weight of Wire per Foot. |
| 7 | .176 | .171 | .109 | .094 | 955 | 1804 | 10.10 | .09 | 0.79 | 0.0243 | .00805 | .33 | 39300 | 74200 | 225000 | 0.11 | 0.90 | .084 |
| 8 | .161 | .157 | .093 | .089 | 810 | 1625 | 10.00 | .07 | 0.50 | 0.0203 | .00650 | .32 | 39900 | 80000 | 250000 | .08 | .58 | .068 |
| 9 | .148 | .145 | .091 | .085 | 779 | 1480 | 10.00 | .07 | 0.56 | 0.0172 | .00608 | .35 | 45300 | 86000 | 244000 | .08 | .64 | .058 |
| 10 | .136 | .135 | .082 | .070 | 774 | 1333 | 9.94 | .03 | 0.36 | 0.0142 | .00451 | .32 | 54500 | 93900 | 296000 | .04 | .42 | .049 |
| 11 | .120 | .118 | .067 | .062 | 685 | 1070 | 10.56 | .10 | 0.42 | 0.0114 | .00326 | .28 | 60100 | 94000 | 328000 | .11 | .46 | .035 |
| 12 | .105 | .105 | .062 | .059 | 524 | 885 | 10.19 | .06 | 0.23 | 0.0086 | .00287 | .33 | 60900 | 102900 | 308000 | .07 | .26 | .029 |
| 13 | .092 | .091 | .054 | .052 | 410 | 695 | 10.10 | .07 | 0.17 | 0.0067 | .00220 | .33 | 61200 | 103700 | 315000 | .08 | .19 | .018 |
| 14 | .078 | .078 | .041 | .039 | 310 | 475 | 9.85 | .08 | 0.24 | 0.0048 | .00126 | .26 | 64600 | 98900 | 378000 | .10 | .28 | .015 |
| 15 | .070 | .070 | .035 | .034 | 215 | 425 | 9.19 | .05 | 0.16 | 0.0038 | .00094 | .25 | 56600 | 111800 | 454000 | .07 | .20 | .013 |
| 16 | .067 | .067 | .029 | .021 | 155 | 427 | 9.75 | .02 | 0.14 | 0.0035 | .00048 | .14 | 44300 | 122000 | 393000 | .03 | .17 | .012 |

# RESULTS OF TESTS FOR ULTIMATE OR BREAKING LOAD OF WIRE ROPES.

## I. Flexible Galvanized Basic Steel Wire Ropes.

| Number of Specimen. | No. of Strand. | No. of Wires in Each Strand. | Gauge, B. W. G. | Circumference, Commercial, Inches. | Circumference, Measured, Inches. | Weight per Foot. | Breaking Load. | Average. |
|---|---|---|---|---|---|---|---|---|
| 1 | 6 | 18 | 17 | $2\frac{1}{2}$ | $2\frac{15}{32}$ | .879 | 18900<br>19900<br>19900 | 19600 |
| 2 | 6 | 19 | 19 | 2 | 2 | .566 | 10240<br>10160<br>10340 | 10250 |
| *3 | 6 | 19 | 20 & 21 | $1\frac{3}{4}$ | $1\frac{23}{32}$ | .397 | 6700<br>6370<br>6500 | 6500 |
| 4 | 6 | 19 | 21 | $1\frac{1}{2}$ | $1\frac{17}{32}$ | .241 | 5550<br>5550<br>5350 | 5480 |
| 5 | 6 | 19 | 22 | $1\frac{1}{4}$ | $1\frac{9}{32}$ | .228 | 3550<br>3570<br>3570 | 3560 |

*9 wires B. W. G. 20. 10 wires B. W. G. 21.

## II. Coarse Galvanized Basic Steel Wire Ropes.

| Number of Specimen. | No. of Strand. | No. of Wires in Each Strand. | Gauge, B. W. G. | Circumference, Commercial, Inches. | Circumference, Measured, Inches. | Weight per Foot. | Breaking Load. | Average. |
|---|---|---|---|---|---|---|---|---|
| 6 | 6 | 7 | 12 | $2\frac{3}{4}$ | $2\frac{13}{16}$ | 1.136 | 26850<br>27300<br>27040 | 27060 |
| 7 | 6 | 7 | 13 | $2\frac{1}{2}$ | $2\frac{9}{16}$ | .96 | 17720<br>18650<br>18300 | 18220 |
| 8 | 6 | 7 | 14 | $2\frac{1}{4}$ | $2\frac{11}{32}$ | .78 | 16100<br>15800<br>16250 | 16020 |
| 9 | 6 | 7 | 15 | 2 | $2\frac{1}{16}$ | .6 | 12170<br>12400<br>12360<br>11780 | 12180 |
| 10 | 6 | 3<br>4 | 15<br>16 | $1\frac{3}{4}$ | $1\frac{27}{32}$ | .462 | 8540<br>8600<br>8800 | 8650 |
| 11 | 6 | 7 | 17 | $1\frac{1}{2}$ | $1\frac{9}{16}$ | .358 | 8120<br>8350<br>8290 | 8250 |
| 12 | 6 | 7 | 18 | $1\frac{1}{4}$ | $1\frac{5}{16}$ | .225 | 4750<br>4810<br>4800 | 4790 |
| 13 | 6 | 7 | 19 | 1 |  | .162 | 3275<br>3320<br>3200 | 3260 |

## III. Flexible Basic Steel Wire Ropes.

| Number of Specimen. | No. of Strand. | No. of Wires in Each Strand. | Gauge, B. W. G. | Circumference, Commercial, Inches. | Circumference, Measured, Inches. | Weight per Foot. | Breaking Load. | Average. |
|---|---|---|---|---|---|---|---|---|
| 14 | 6 | 19 | 17 | $2\frac{1}{2}$ | $2\frac{19}{32}$ | .949 | 24350<br>23700<br>23000 | 23680 |
| 15 | 6 | 19 | 18 | $2\frac{3}{8}$ | $2\frac{15}{32}$ | .846 | 21250<br>21010<br>22270 | 21510 |
| 16 | 6 | 19 | 18 | $2\frac{1}{4}$ | $2\frac{11}{32}$ | .81 | 20000<br>20200<br>19170 | 19790 |
| 17 | 6 | 19 | 19 | 2 | $2\frac{1}{32}$ | .588 | 16200<br>16750<br>16840<br>17580 | 17060 |
| 18 | 6 | 19 | 20 | $1\frac{3}{4}$ | $1\frac{3}{4}$ | .439 | 11050<br>15000<br>14900 | 13650 |
| 19 | 6 | 19 | 21 | $1\frac{1}{2}$ | $1\frac{9}{16}$ | .397 | 10620<br>10550<br>11200 | 10790 |

## IV. Coarse Basic Steel.

| Number of Specimen. | No. of Strand. | No. of Wires in Each Strand. | Gauge, B. W. G. | Circumference, Commercial, Inches. | Circumference, Measured, Inches. | Weight per Foot. | Breaking Load. | Average. |
|---|---|---|---|---|---|---|---|---|
| 20 | 6 | 7 | 15 | 2 | $2\frac{1}{16}$ | .642 | 18500<br>18800<br>18710<br>19250 | 18820 |
| 21 | 6 | 7 | 16 | $1\frac{3}{4}$ | $1\frac{7}{8}$ | .505 | 15000<br>15620<br>15900 | 15510 |
| 22 | 6 | 7 | 17 | $1\frac{1}{2}$ | $1\frac{17}{32}$ | .33 | 9800<br>9910<br>10300 | 10000 |
| 23 | 6 | 7 | 19 | $1\frac{1}{4}$ |  | .21 | 6400<br>6600<br>6100 | 6370 |

## V. Flexible Crucible Steel Wire Ropes.

| Number of Specimen. | No. of Strand. | No. of Wires in Each Strand. | Gauge, B. W. G. | Circumference, Commercial, Inches. | Circumference, Measured, Inches. | Weight per Foot. | Breaking Load. | Average. |
|---|---|---|---|---|---|---|---|---|
| 24 | 6 | 19 | 20 | $1\frac{3}{4}$ | $1\frac{13}{16}$ | .484 | 24300<br>23700<br>23300 | 23770 |
| 25 | 6 | 19 | 21 | $1\frac{1}{2}$ | $1\frac{7}{16}$ | .365 | 18900<br>19900<br>16900 | 18570 |
| 26 | 6 | 19 | 22 | $1\frac{1}{4}$ |  | .248 | 11020<br>10300<br>10900 | 10740 |
| 34 | 6 | 19 | 18 | $2\frac{1}{4}$ | $2\frac{7}{32}$ | .70 | 40050<br>37900 | 38980 |
| 35 | 6 | 19 | 19 | 2 | $2\frac{3}{32}$ | .645 | 30450<br>30050<br>29650 | 30050 |

## VI. Coarse Crucible Stèel Wire Ropes.

| Number of Specimen. | No. of Strand. | No. of Wires in Each Strand. | Gauge, B. W. G. | Circumference, Commercial, Inches. | Circumference, Measured, Inches. | Weight per Foot. | Breaking Load. | Average. |
|---|---|---|---|---|---|---|---|---|
| 27 | 6 | 7 | 14 | $2\frac{1}{4}$ | $2\frac{5}{16}$ | .832 | 40800<br>41300<br>39410 | 40500 |
| 28 | 6 | 7 | 15 | 2 | $2\frac{1}{16}$ | .648 | 30600<br>31300<br>32000 | 31300 |
| 29 | 6 | 7 | 16 | $1\frac{3}{4}$ | $1\frac{13}{16}$ | .495 | 25310<br>25690<br>25700 | 25570 |
| *30 | 6 | 6 | 17 | $1\frac{1}{2}$ | $1\frac{1}{2}$ | .295 | 10500<br>10000<br>11200 | 10570 |
| 31 | 6 | 7 | 18 | $1\frac{1}{4}$ |  | .184 | 8700<br>8390<br>8360 | 8480 |
| 32 | 6 | 7 | 19 | 1 |  | .169 | 5650<br>5970<br>6390 | 6000 |

* Each strand contains a hemp core.

The following tables contain the data necessary for ascertaining what properly may be called the "efficiency" of the rope or strand.

The efficiency serves as a relative measure, as a criterion regarding the methods adopted and the character of the work in the manufacture of the rope, etc., and is independent of the quality of the material used.

The section of the rope is to the total section of the wires which form it, inversely as their length. The strength of a "perfect" rope is therefore greater, in the above proportion, than the combined strength of the individual wires composing it.

As a standard of comparison for any particular rope or strand, I have therefore adopted the above defined "ideal" or "perfect rope."

Let $B$ equal the sum of the breaking loads of all the wires composing the rope.
$B_1$ " " breaking load of rope.
$B_2$ " " breaking load of strand.
$B_3$ " " sum of breaking loads of all the wires composing the strand.
$B_4$ " " sum of breaking loads of all the wires composing the rope.
$L$ " " length of wire.
$L_1$ " " length of rope.
$L_2$ " " length of strand.

$S$ denotes the sum of sections of wires composing either strand or rope, as may be required.

$S_1$ denotes section of rope.

$S_2$ denotes section of strand or strands, as may be required.

We have the following relations:

$$S_1\,l_1 = S\,l \qquad \frac{S_1}{S} = \frac{l}{l_1}$$

$$S_2\,l_2 = S_1\,l_1 \qquad \frac{S_2}{S_1} = \frac{l_1}{l_2}$$

$$S\,l = S_2\,l_2 \qquad \frac{S}{S_2} = \frac{l_2}{l}$$

In the above sense we may speak of the efficiency of a rope or of a strand, with regard to their respective wires; or we may speak of the efficiency of the rope as relating to its strands only.

To determine, for instance, the efficiency of a rope with respect to the wires composing it, we have the total breaking load of its wires per unit of area equal to $\frac{B}{S}$; hence the breaking load of a perfect rope equal to $\frac{B\,S_1}{S}$ or equal to $\frac{b\,l}{l_1}$; hence the efficiency will be equal to $\frac{B_1\,l_1}{B\,l}$.

These efficiencies were determined for the specimens given in the following table. The other tables contain the data required for computation.

| | No. of Specimen. | No. of Strands. | No. of Wires in Each Strand. | Length of Rope. | Length of Strand. | Length of Wire. | Breaking Load. Pounds. |
|---|---|---|---|---|---|---|---|
| Flexible Basic Steel Wire Rope. . . . | 17 | 6 | 19 | 12.66 | 12.84 | 13.16 | 17060 |
| Flexible Crucible Steel Wire Rope. . | 35 | 6 | 19 | 12.06 | 12.53 | 12.78 | 30050 |
| Flexible Basic Steel Gal. Wire Rope. | 2 | 6 | 19 | 12.06 | 13.16 | 13.44 | 10250 |
| Coarse Crucible Steel Wire Rope. . . . | 28 | 6 | 7 | 12.00 | 12.31 | 12.38 | 31300 |
| Coarse Basic Steel Gal. Wire Rope. . | 9 | 6 | 7 | 12.78 | 13.09 | 13.34 | 12180 |
| Coarse Basic Steel Wire Rope. . . . . . . | 20 | 6 | 7 | 11.40 | 12.34 | 12.47 | 18910 |

The following tables refer to six different qualities of wire rope, composed of six strands each, and contain the breaking load of each strand, and also the diameters and breaking loads of each wire composing the strand.

## Flexible Basic Steel Wire Ropes.

### BREAKING LOAD OF STRANDS.

| Strand No 1. 2,400 lbs. | | Strand No. 2. 3,200 lbs. | | Strand No. 3. 2,750 lbs. | | Strand No. 4. 2,800 lbs. | | Strand No. 5. 2,900 lbs. | | Strand No. 6. 2,950 lbs. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Diameter, Inches. | Breaking Load. | Diameter, Inches. | Breaking Load. | Diameter, Inches. | Breaking Load. | Diameter, Inches. | Breaking Load. | Diameter, Inches. | Breaking Load. | Diameter, Inches. | Breaking Load. |
| .046 | 169 | .045 | 152 | .045 | 165 | .043 | 158 | .046 | 174 | .046 | 171 |
| .046 | 143 | .046 | 185 | .045 | 168 | .045 | 156 | .046 | 175 | .046 | 168 |
| .045 | 150 | .045 | 170 | .044 | 161 | .046 | 170 | .045 | 174 | .045 | 167 |
| .046 | 169 | .045 | 160 | .046 | 188 | .046 | 162 | .045 | 174 | .045 | 178 |
| .044 | 160 | .045 | 170 | .044 | 140 | .046 | 175 | .046 | 170 | .047 | 188 |
| .044 | 173 | .046 | 173 | .045 | 154 | .046 | 162 | .046 | 158 | .045 | 154 |
| .045 | 175 | .044 | 156 | .045 | 168 | .045 | 166 | .047 | 172 | .045 | 172 |
| .044 | 171 | .046 | 175 | .044 | 155 | .044 | 155 | .047 | 183 | .046 | 157 |
| .045 | 168 | .046 | 171 | .047 | 186 | .045 | 125 | .046 | 170 | .045 | 174 |
| .046 | 161 | .047 | 197 | .045 | 170 | .046 | 168 | .046 | 175 | .047 | 167 |
| .045 | 170 | .046 | 167 | .044 | 151 | .046 | 174 | .047 | 167 | .045 | 174 |
| .046 | 172 | .047 | 193 | .044 | 174 | .047 | 197 | .046 | 184 | .045 | 177 |
| .044 | 151 | .045 | 173 | .045 | 173 | .045 | 174 | .045 | 175 | .044 | 176 |
| .045 | 160 | .045 | 174 | .046 | 177 | .046 | 160 | .046 | 158 | .045 | 157 |
| .046 | 180 | .045 | 170 | .045 | 173 | .045 | 175 | .045 | 169 | .045 | 163 |
| .044 | 160 | .046 | 179 | .045 | 165 | .047 | 189 | .046 | 165 | .047 | 160 |
| .046 | 174 | .047 | 168 | .045 | 163 | .047 | 218 | .046 | 150 | .045 | 168 |
| .045 | 155 | .045 | 145 | .046 | 167 | -046 | 168 | .044 | 152 | .045 | 170 |
| .045 | 168 | .046 | 185 | .045 | 165 | .047 | 185 | .045 | 153 | .047 | 180 |
| | 3029 | | 3259 | | 3165 | | 3277 | | 3198 | | 3221 |

## Flexible Crucible Steel Rope.

### BREAKING LOAD OF STRANDS.

| Strand No. 1. 4,810 lbs. | | Strand No. 2. 5,150 lbs. | | Strand No. 3. 4,850 lbs. | | Strand No. 4. 5,430 lbs. | | Strand No. 5. 5,040 lbs. | | Strand No. 6. 5,730 lbs. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Diameter, Inches. | Breaking Load. | Diameter, Inches. | Breaking Load. | Diameter, Inches. | Breaking Load. | Diameter, Inches. | Breaking Load. | Diameter, Inches. | Breaking Load. | Diameter, Inches. | Breaking Load. |
| .053 | 179 | .055 | 160 | .051 | 148 | .051 | 179 | .050 | 153 | .052 | 175 |
| .048 | 293 | .047 | 303 | .046 | 284 | .046 | 325 | .047 | 301 | .047 | 325 |
| .046 | 310 | .047 | 348 | .048 | 345 | .047 | 330 | .047 | 294 | .047 | 332 |
| .047 | 308 | .048 | 298 | .048 | 316 | .047 | 300 | .048 | 344 | .048 | 340 |
| .048 | 377 | .046 | 339 | .047 | 305 | .047 | 280 | .048 | 350 | .047 | 305 |
| .046 | 300 | .047 | 375 | .048 | 350 | .046 | 298 | .047 | 325 | .046 | 309 |
| .046 | 294 | .046 | 290 | .048 | 348 | .045 | 350 | .046 | 290 | .046 | 301 |
| .047 | 314 | .047 | 300 | .047 | 301 | .048 | 323 | .050 | 390 | .048 | 335 |
| .047 | 312 | .047 | 286 | .048 | 320 | .048 | 326 | .047 | 298 | .046 | 296 |
| .047 | 285 | .045 | 288 | .048 | 320 | .048 | 330 | .047 | 313 | .047 | 308 |
| .048 | 315 | .046 | 321 | .046 | 288 | .048 | 340 | .048 | 335 | .048 | 362 |
| .049 | 349 | .047 | 364 | .048 | 348 | .048 | 332 | .047 | 309 | .047 | 325 |
| .047 | 325 | .047 | 279 | .045 | 274 | .047 | 310 | .048 | 315 | .047 | 312 |
| .047 | 341 | .047 | 336 | .047 | 351 | .046 | 282 | .046 | 293 | .048 | 340 |
| .047 | 333 | .046 | 376 | .047 | 340 | .047 | 299 | .048 | 337 | .046 | 291 |
| .048 | 294 | .048 | 341 | .048 | 379 | .048 | 337 | .046 | 295 | .047 | 298 |
| .048 | 285 | .046 | 276 | .046 | 283 | .047 | 295 | .047 | 310 | .048 | 338 |
| .050 | 361 | .046 | 339 | .047 | 296 | .047 | 330 | .047 | 308 | .046 | 281 |
| .048 | 314 | .047 | 324 | .046 | 288 | .048 | 347 | .048 | 335 | .047 | 330 |
| | 5894 | | 5943 | | 5884 | | 5913 | | 5860 | | 5953 |

# Flexible Galvanized Basic Steel Wire Rope.

## BREAKING LOAD OF STRANDS.

| Strand No. 1. 1,830 lbs. | | Strand No. 2. 1,810 lbs. | | Strand No. 3. 1,820 lbs. | | Strand No. 4. 1,860 lbs. | | Strand No. 5. 1,790 lbs. | | Strand No. 6. 1,830 lbs. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Diameter, Inches. | Breaking Load. | Diameter, Inches. | Breaking Load. | Diameter. Inches. | Breaking Load. | Diameter, Inches. | Breaking Load. | Diameter, Inches. | Breaking Load. | Diameter, Inches. | Breaking Load. |
| .039 | 100 | .041 | 109 | .040 | 99 | .042 | 102 | .040 | 94 | .040 | 97 |
| .040 | 98 | .043 | 102 | .040 | 96 | .041 | 113 | .041 | 102 | .042 | 92 |
| .042 | 110 | .041 | 92 | .042 | 94 | .041 | 98 | .041 | 110 | .041 | 78 |
| .041 | 100 | .040 | 102 | .042 | 110 | .040 | 95 | .041 | 90 | .041 | 112 |
| .040 | 100 | .043 | 96 | .035 | 76 | .041 | 117 | .041 | 103 | .040 | 100 |
| .041 | 104 | .040 | 101 | .039 | 107 | .041 | 130 | .040 | 117 | .040 | 113 |
| .041 | 87 | .041 | 107 | .040 | 100 | .040 | 96 | .042 | 95 | .040 | 103 |
| .041 | 108 | .040 | 101 | .041 | 96 | .040 | 96 | .041 | 108 | .040 | 103 |
| .042 | 98 | .040 | 103 | .040 | 100 | .041 | 95 | .039 | 94 | .040 | 108 |
| .042 | 130 | .041 | 94 | .042 | 120 | .042 | 102 | .035 | 68 | .040 | 123 |
| .040 | 104 | .041 | 96 | .040 | 96 | .041 | 93 | .042 | 101 | .041 | 96 |
| .041 | 93 | .042 | 107 | .042 | 98 | .040 | 112 | .041 | 96 | .041 | 102 |
| .040 | 103 | .040 | 98 | .041 | 90 | .041 | 92 | .040 | 95 | .042 | 101 |
| .038 | 101 | .039 | 97 | .040 | 115 | .041 | 100 | .043 | 97 | .040 | 98 |
| .040 | 99 | .039 | 106 | .042 | 125 | .040 | 106 | .042 | 93 | .040 | 95 |
| .040 | 109 | .040 | 96 | 041 | 115 | .040 | 100 | .041 | 112 | .041 | 95 |
| .039 | 113 | .040 | 96 | .041 | 102 | .041 | 106 | .042 | 93 | .041 | 104 |
| .039 | 104 | .040 | 131 | .040 | 84 | .041 | 97 | .040 | 95 | .039 | 87 |
| .040 | 112 | .040 | 126 | .041 | 135 | .039 | 92 | .039 | 97 | .040 | 95 |
| | 1973 | | 1960 | | 1958 | | 1942 | | 1860 | | 1902 |

## Coarse Crucible Steel Wire Rope.

### BREAKING LOAD OF STRANDS.

| Strand No. 1.<br>4,560 lbs. | | Strand No. 2.<br>5,370 lbs. | | Strand No. 3.<br>4,880 lbs. | | Strand No. 4.<br>4,830 lbs. | | Strand No. 5.<br>4,910 lbs. | | Strand No. 6<br>5,390 lbs. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Diameter, Inches. | Breaking Load. | Diameter, Inches. | Breaking Load. | Diameter, Inches. | Breaking Load. | Diameter, Inches. | Breaking Load. | Diameter, Inches. | Breaking Load. | Diameter, Inches. | Breaking Load. |
| *.071 | 287 | .075 | 587 | .074 | 957 | .070 | 500 | .074 | 228 | .072 | 212 |
| .071 | 788 | .071 | 972 | .074 | 1022 | .071 | 790 | .071 | 975 | .072 | 1050 |
| .071 | 893 | .073 | 1034 | .072 | 880 | .074 | 992 | .071 | 793 | .071 | 880 |
| .071 | 917 | .071 | 850 | .070 | 833 | .074 | 1050 | .071 | 850 | .070 | 820 |
| .072 | 992 | .072 | 1018 | .075 | 600 | .073 | 895 | .071 | 850 | .071 | 960 |
| .071 | 893 | .069 | 899 | .073 | 897 | .071 | 960 | .071 | 829 | .070 | 999 |
| .069 | 949 | .071 | 874 | .072 | 987 | .070 | 850 | .071 | 800 | .070 | 860 |
| | 5749 | | 5647 | | 6176 | | 6037 | | 5325 | | 5781 |

*Core of Soft Iron.

## Coarse Basic Steel Galvanized Wire Rope.

### BREAKING LOAD OF STRANDS.

| Strand No. 1.<br>2,220 lbs. | | Strand No. 2.<br>2,150 lbs. | | Strand No. 3.<br>2,070 lbs. | | Strand No. 4.<br>2,060 lbs. | | Strand No. 5.<br>1,990 lbs. | | Strand No. 6.<br>2,210 lbs. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| .075 | 406 | .069 | 280 | .069 | 283 | .070 | 325 | .070 | 310 | .071 | 310 |
| .069 | 270 | .071 | 325 | .073 | 341 | .070 | 297 | .068 | 277 | .067 | 275 |
| .070 | 326 | .071 | 295 | .070 | 314 | .070 | 291 | .067 | 319 | .068 | 281 |
| .069 | 270 | .070 | 385 | .069 | 298 | .070 | 294 | .070 | 291 | .069 | 300 |
| .071 | 320 | .069 | 335 | .066 | 285 | .071 | 279 | .071 | 292 | .069 | 396 |
| .070 | 294 | .070 | 325 | .069 | 280 | .071 | 286 | .068 | 278 | .070 | 298 |
| .070 | 318 | .071 | 402 | .071 | 328 | .069 | 264 | .070 | 298 | .077 | 292 |
| | 2206 | | 2347 | | 2129 | | 2036 | | 2065 | | 2152 |

## Coarse Basic Steel Wire Rope.

### BREAKING LOAD OF STRANDS.

| Strand No. 1.<br>3,480 lbs. | | Strand No. 2.<br>2,640 lbs. | | Strand No. 3.<br>3,440 lbs. | | Strand No. 4.<br>3,000 lbs. | | Strand No. 5.<br>3,460 lbs. | | Strand No. 6.<br>3,150 lbs. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Diameter, Inches. | Breaking Load. | Diameter, Inches. | Breaking Load. | Diameter, Inches. | Breaking Load. | Diameter, Inches. | Breaking Load. | Diameter, Inches. | Breaking Load. | Diameter, Inches. | Breaking Load. |
| .071 | 479 | .071 | 386 | .073 | 567 | .071 | 398 | .073 | 540 | .073 | 527 |
| .073 | 550 | .071 | 462 | .072 | 560 | .070 | 550 | .072 | 465 | .070 | 440 |
| .073 | 525 | .071 | 426 | .071 | 479 | .070 | 400 | .071 | 415 | .071 | 545 |
| .071 | 485 | .072 | 611 | .072 | 500 | .072 | 516 | .071 | 523 | .073 | 552 |
| .072 | 400 | .072 | 550 | .071 | 461 | .073 | 570 | .071 | 510 | .070 | 410 |
| .072 | 435 | .072 | 435 | .074 | 553 | .073 | 506 | .071 | 485 | .071 | 538 |
| .073 | 478 | .070 | 318 | .074 | 450 | .072 | 516 | .072 | 519 | .070 | 480 |
| | 3352 | | 3188 | | 3470 | | 3456 | | 3457 | | 3492 |

## TABLES OF EFFICIENCY.

### EFFICIENCY OF ROPE AS COMPARED TO THE WIRES COMPRISING IT $= \eta$.

| | $B_1$ | $B$ | $l$ | $l_1$ | $\frac{B_1}{B}$ | $\frac{l_1}{l}$ | $\eta=\frac{B_1\,l_1}{B\;\,l}$ |
|---|---|---|---|---|---|---|---|
| Flexible Basic Steel Rope. . | 17060 | 19250 | 13.16 | 12.66 | .89 | .96 | .85 |
| Flexible Crucible Steel Rope | 29370 | 35450 | 12.78 | 12.06 | .83 | .94 | .78 |
| Flex. Basic Steel Gal. Rope. | 10250 | 11400 | 13.44 | 12.06 | .90 | .88 | .80 |
| Coarse Crucible Steel Rope. | 31300 | 34700 | 12.38 | 12.00 | .90 | .97 | .88 |
| Coarse Basic Steel Gal. Rope | 12180 | 12940 | 13.34 | 12.78 | .94 | .95 | .90 |
| Coarse Basic Steel Rope.... | 18910 | 20420 | 12.47 | 11.40 | .93 | .92 | .86 |

### EFFICIENCY OF ROPE AS COMPARED TO STRANDS COMPOSING IT.

| | $B_1$ | $B_4$ | $l_2$ | $l_1$ | $\frac{B_1}{B_4}$ | $\frac{l_1}{l_2}$ | $\eta=\frac{B_1\,l_1}{B_4\,l_2}$ |
|---|---|---|---|---|---|---|---|
| Flexible Wire Rope........ | 17060 | 17000 | 12.84 | 12.66 | 1.00 | .99 | .99 |
| " Steel " ...... | 29370 | 31010 | 12.53 | 12.06 | .95 | .96 | .91 |
| " Galvanized Rope... | 10250 | 10940 | 13.16 | 12.06 | .94 | .92 | .87 |
| Coarse Steel Rope.......... | 31300 | 29940 | 12.31 | 12.00 | 1.04 | .98 | 1.00 |
| " Galvanized Rope.... | 12180 | 12730 | 13.09 | 12.78 | .96 | .98 | .94 |
| " Wire Rope.......... | 18910 | 19170 | 12.34 | 11.40 | .98 | .93 | .91 |

### EFFICIENCY OF STRANDS AS COMPARED TO WIRE COMPOSING THEM.

**Flexible Basic Steel Wire Rope.**

| No. of Strand | $B_2$ | $B_3$ | $l_2$ | $l$ | $\frac{B_2}{B_3}$ | $\frac{l_2}{l}$ | $\eta=\frac{B_2\,l_2}{B_3\,l}$ | Aver'ge Effic'y. |
|---|---|---|---|---|---|---|---|---|
| 1 | 2400 | 3129 | 12.84 | 13.16 | .77 | .98 | .75 | 86.5 |
| 2 | 3200 | 3260 | 12.84 | 13.16 | .98 | .98 | .96 | |
| 3 | 2750 | 3170 | 12.84 | 13.16 | .87 | .98 | .85 | |
| 4 | 2800 | 3280 | 12.84 | 13.16 | .86 | .98 | .84 | |
| 5 | 2900 | 3200 | 12.84 | 13.16 | .91 | .98 | .89 | |
| 6 | 2950 | 3220 | 12.84 | 13.16 | .92 | .98 | .90 | |

## EFFICIENCY OF STRANDS AS COMPARED TO WIRE COMPOSING THEM.

### Flexible Crucible Steel Strands.

| No. of Strand | $B_2$ | $B_3$ | $l_2$ | $l$ | $\frac{B_2}{B_3}$ | $\frac{l_2}{l}$ | $\eta$ | Aver'ge |
|---|---|---|---|---|---|---|---|---|
| 1 | 4810 | 5890 | 12.53 | 12.78 | .82 | .98 | .80 | .86 |
| 2 | 5150 | 5940 | 12.53 | 12.78 | .87 | .98 | .85 | |
| 3 | 4850 | 5880 | 12.53 | 12.78 | .83 | .98 | .81 | |
| 4 | 5430 | 5910 | 12.53 | 12.78 | .92 | .98 | .90 | |
| 5 | 5040 | 5860 | 12.53 | 12.78 | .86 | .98 | .84 | |
| 6 | 5730 | 5950 | 12.53 | 12.78 | .96 | .98 | .94 | |

### Flexible Galvanized Basic Steel Strands.

| No. of Strand | $B_2$ | $B_3$ | $l_2$ | $l$ | $\frac{B_2}{B_3}$ | $\frac{l_2}{l}$ | $\eta$ | Aver'ge |
|---|---|---|---|---|---|---|---|---|
| 1 | 1830 | 1970 | 13.16 | 13.44 | .93 | .98 | .91 | .93 |
| 2 | 1810 | 1960 | 13.16 | 13.44 | .92 | .98 | .91 | |
| 3 | 1820 | 1960 | 13.16 | 13.44 | .93 | .98 | .91 | |
| 4 | 1860 | 1940 | 13.16 | 13.44 | .96 | .98 | .94 | |
| 5 | 1790 | 1860 | 13.16 | 13.44 | .96 | .98 | .94 | |
| 6 | 1830 | 1900 | 13.16 | 13.44 | .96 | .98 | .94 | |

### Coarse Crucible Steel Strands.

| No. of Strand | $B_2$ | $B_3$ | $l_2$ | $l$ | $\frac{B_2}{B_3}$ | $\frac{l_2}{l}$ | $\eta$ | Aver'ge |
|---|---|---|---|---|---|---|---|---|
| 1 | 4560 | 5750 | 12.31 | 12.38 | .89 | .99 | .88 | .87 |
| 2 | 5370 | 5650 | 12.31 | 12.38 | .95 | .99 | .94 | |
| 3 | 4880 | 6180 | 12.31 | 12.38 | .79 | .99 | .78 | |
| 4 | 4830 | 6040 | 12.31 | 12.38 | .80 | .99 | .79 | |
| 5 | 4910 | 5330 | 12.31 | 12.38 | .92 | .99 | .91 | |
| 6 | 5390 | 5780 | 12.31 | 12.38 | .93 | .99 | .92 | |

## EFFICIENCY OF STRANDS AS COMPARED TO WIRE COMPOSING THEM.

### Coarse Basic Steel Galvanized Strands.

| No. of Strand | $B_2$ | $B_3$ | $l_2$ | $l$ | $\frac{B_2}{B_3}$ | $\frac{l_2}{l}$ | $\eta$ | Aver'ge |
|---|---|---|---|---|---|---|---|---|
| 1 | 2220 | 2210 | 13.09 | 13.34 | 1.00 | .98 | .98 | .97 |
| 2 | 2150 | 2350 | 13.09 | 13.34 | .92 | .98 | .90 | |
| 3 | 2070 | 2130 | 13.09 | 13.34 | .98 | .98 | .96 | |
| 4 | 2060 | 2040 | 13.09 | 13.34 | 1.01 | .98 | .99 | |
| 5 | 1990 | 2070 | 13.09 | 13.34 | .97 | .98 | .95 | |
| 6 | 2210 | 2150 | 13.09 | 13.34 | 1.03 | .98 | 1.00 | |

### Coarse Iron Basic Steel Strands.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | 3480 | 3350 | 12.34 | 12.47 | 1.04 | .98 | 1.02 | .92 |
| 2 | 2640 | 3190 | 12.34 | 12.47 | .83 | .98 | .81 | |
| 3 | 3440 | 3470 | 12.34 | 12.47 | .99 | .98 | .99 | |
| 4 | 3000 | 3460 | 12.34 | 12.47 | .87 | .98 | .85 | |
| 5 | 3460 | 3460 | 12.34 | 12.47 | 1.00 | .98 | .98 | |
| 6 | 3150 | 3490 | 12.34 | 12.47 | .90 | .98 | .88 | |

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